"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Power Systems)"

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AUTOMATED SOLAR TRACKING SYSTEM USING PLC

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A thesis submitted
in fulfillment of the requirements for the award of the degree of
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To my beloved mother, father and Diana

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ABSTRACT

In our daily life, the need of energy increases each and every day. The source of electricity is commonly from motor generators that is generate from the source of coal or other element of fuel. Another new way in this era is by using solar energy. The solar energy convert solar irradiation to power that can be used in common electric appliances. Since solar is a new type of source, the usage of the solar is still small compare to the old conventional ways. The solar energy is converted when the solar cells on the solar panel detects light irradiation. However, the angle of the sun is proportional to the energy converted. If the sun is 90° vertical to the solar panel, the energy received is maximum compare to other angles. In this case, a project is developed to track the solar during the movement of the sun from morning till night. The ASTS (Automated Solar Tracking System) is developed by moving the solar panel during anytime of the day that the sun is available and the motor will move the panel to a 90° vertical angle directly to the sun. The system is controlled by OMRON Programmable Logic Controller which will process data from the sensor and convert it to output for the motor movement. As the result, a prototype of Automated Solar Tracking System is operated and able to achieve the objective of this project.

ABSTRAK

Dalam kehidupan harian, penggunaan tenaga bertambah dari hari ke hari. Punca tenaga elektrik sebahagian besar adalah daripada generator motor yang mendapat bahan bakat daripada pembakaran arang atau bahan bakar yang lain. Satu cara baru di zaman ini adalah dengan penggunaan tenaga solar. Tenaga solar adalah ditukar daripada radiasi cahaya matahari kepada tenaga elektrik yang boleh digunakan oleh perkakas elektrik yang biasa digunakan seharian. Disebabkan tenaga solar adalah satu sumber tenaga yang baru, oleh itu penggunaan tenaga solar masih sedikit berbanding dengan penggunaan tenaga daripada bahan bakar.Tenaga solar diproses apabila tenaga radiasi matahri dikesan. Walaubagaimanapun, sudut matahari berkadar terus dengan tenaga elektrik yang dihasilkan. Jika sudut matahari adalah 90° kepada solar panel, tenaga yang diproses adalah maksimum berbanding dengan sudut yang lain.Dalam kes ini, sebuah projek dibina untuk mengesan matahari apabila ia bergerak daripada pagi hingga ke malam. Projek ’Automated Solar Tracking System ’ dibina untuk mengesan matahari pada waktu pagi dan ia akan menggereakkan motor untuk memposisikan solar panel 90° kepada cahaya matahari. Sistem ini dikendali oleh OMRON ’Programmable Logic Controller’yang akan memproses data daripada sensor dan mendapatkan output untuk menggerakkan motor. Diakhir projek, sebuah prototaip Automated Solar Tracking System Berjaya dihasilkan yang mengikut objektif projek.

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

The sun is a low cost source of electricity for instead of using generators, solar panel can convert direct sun rays to electricity. Conventional solar panel, fixed with a certain angle, limits their area of exposure from the sun due to rotation of the earth. Output of the solar cells depends on the intensity of the sun and the angle of incidence.

In pursuing to get the maximum energy converted from the sun, an automated system is required which should be capable to constantly rotate the solar panel. The Automatic Sun Tracking System (ASTS) is a project meant to solve this problem. It is completely automatic and keeps the panel parallel to the sun.

In this project, it the ASTS takes the sun as a guiding source. Sensors are used to constantly monitor the sunlight and rotate the solar panel to the maximum intensity of sunlight. PLC (Programmable Logic Controller) is used as a device for controlling the output for the motor. If the sun is not visible during a short period due to cloudy weather, the PLC is set with a program which will engage the motor rotation to halt which only will be reactivated due to a sensor which will detect availability of the sun to continue its next cycle.

1.2 RESEARCH OBJECTIVES

This study attempts to achieve the following objective:

i. To develop a solar tracker with optimum tracking from the sun.

ii. Positioning of solar panel through stepper motor control using PLC.

iii. Result for the efficiency of the device.

1.3 SCOPE OF PROJECT

This project is focused to develop and build an Automated Solar Tracking System (ASTS) by using plc to move the DC motor that will direct the solar panel from east to west and back to its initial. Therefore, the project scope is as follow.

i. An automated tracking system which detects the sun during daylight.

ii. Use PLC to move the motor clockwise or counterclockwise.

iii. Show result by differentiate with other angle reading.(45 , 90 , 135)

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1.4 PROBLEM STATEMENT

This study aims to seek the following research:

i. The sun is moving 180º from east to west so the light irradiation is varied due to the rotation cycle of the earth.

ii. A solar panel which is static for instant 45º (east/west) will only take the light irradiation w/m² at the first 90º or the end 180º therefore the maximum power for the solar panel does not occur.

1.5 THESIS ORGANIZATION

This thesis consists of five chapters. This chapter discuss about overview of project, objective research, project scope, problem statement and thesis organization.

Chapter 2 contains a detailed description and idea of Automated Solar Tracking System using PLC or other device. It will explain about the concept of sun tracking using LDR for maximum light power, the advantage of this system and the involved component in this project.

Chapter 3 includes the project methodology. It will explain how the project is organized and the flow of process in completing this project. Also in this topic discusses the methodology of the system, step to develop the system, and device used to measure the light irradiation and angle of solar panel during each data taken.

Chapter 4 will be discussing about the result obtained in this project and a discussion about the result.

Finally, the conclusions for this project are presented in chapter 5. This chapter also discusses about the recommendation for the project and for the future development.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Solar panel is a board that contains many solar cells. These two sensors are mounted in “V” shape as in figure 1 exactly in the middle of the solar panel. The automatic sun tracking is accomplished according to following 3-step diagram. There is 2 sensors used in this project. The idea of using the sensor is selecting two most appropriate types which in this case the use of LDR (Light Dependant Resistor) which sense light energy. Since these sensors give resistance proportional to light efficiency, we can use a circuit to conduct the system. [2]

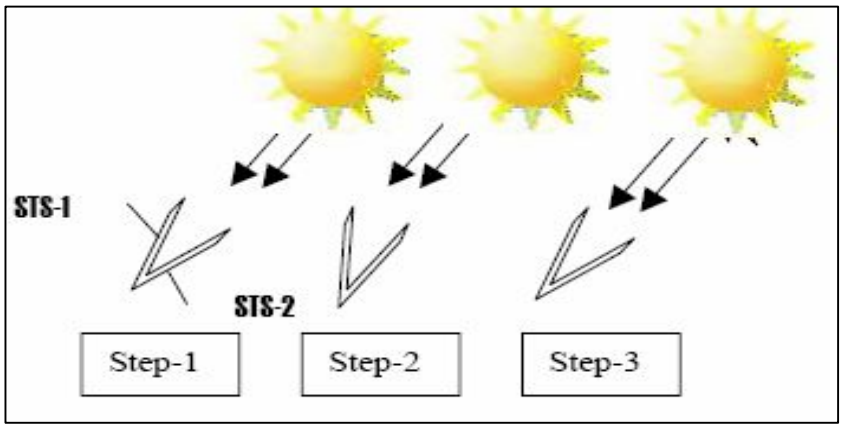

Figure 2.1: Basic Automatic Sun Tracking System.

Step-1 shows that when the sun is in front of solar panel, both sensors which is STS-1 and STS-2 are getting same amount of light. In step-2, after some time as the earth rotates the solar panel gets repositioned with respect to sun and STS-1 obtains less amount of light. At this point the STS-1 sends signal to the circuit. Then the circuit will sends data to the PLC and process it to rotate the stepper motor, result in the rotation of solar panel towards the sun. Finally step-3 shows the reorientation of solar panel. Finally step-3 shows the reorientation of solar panel. The process continues until the end of day.[2]

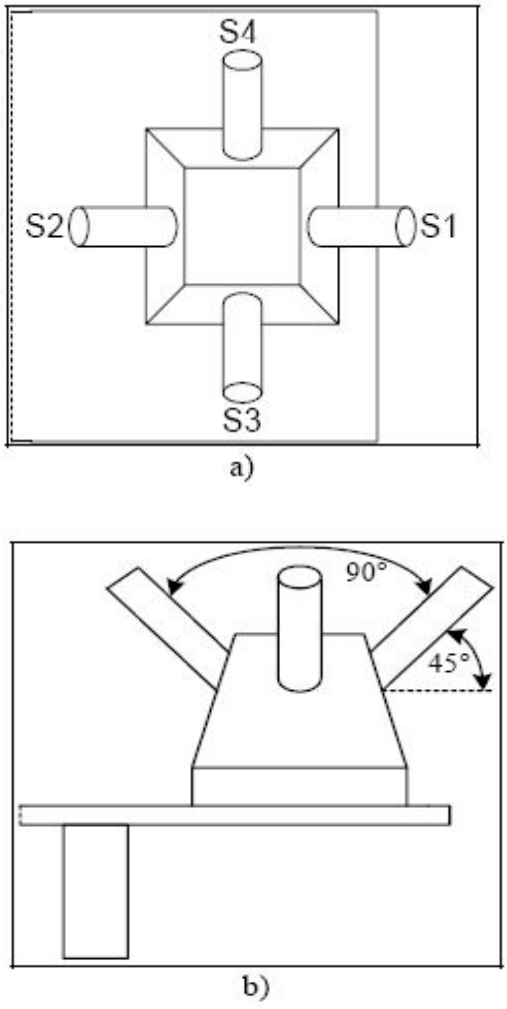

Figure 2.2: LDR assembly a) Top view b) Front

Figure 2.3: A photograph of ASTS.

Image Processing provides a comprehensive set of reference-standard algorithms and graphical tools for image processing, analysis, visualization, and algorithm development. You can restore noisy or degraded images, enhance images for improved intelligibility, extract features, analyze shapes and textures, and register two images. Image Processing Toolbox supports engineers and scientists in areas such as biometrics, remote sensing, surveillance, gene expression, microscopy, semiconductor testing, image sensor design, colour science, and materials science. It also facilitates the learning and teaching of image processing techniques. Image processing is any form of signal processing for which the input is an image, such as photographs or frames of video the output of image processing can be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.[2]

2.2 Light Dependent Resistor

A photoresistor or light dependent resistor or cadmium sulfide (CdS) cell is a resistor whose resistance decreases with increasing incident light intensity. It can also be referenced as a photoconductor. [7]

A photoresistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance. [7]

A photoelectric device can be either intrinsic or extrinsic. An intrinsic semiconductor has its own charge carriers and is not an efficient semiconductor, e.g. silicon. In intrinsic devices the only available electrons are in the valence band, and hence the photon must have enough energy to excite the electron across the entire bandgap. Extrinsic devices have impurities, also called dopants, and added whose ground state energy is closer to the conduction band; since the electrons do not have as far to jump, lower energy photons (i.e., longer wavelengths and lower frequencies) are sufficient to trigger the device. If a sample of silicon has some of its atoms replaced by phosphorus atoms (impurities), there will be extra electrons available for conduction. This is an example of an extrinsic semiconductor. [7]

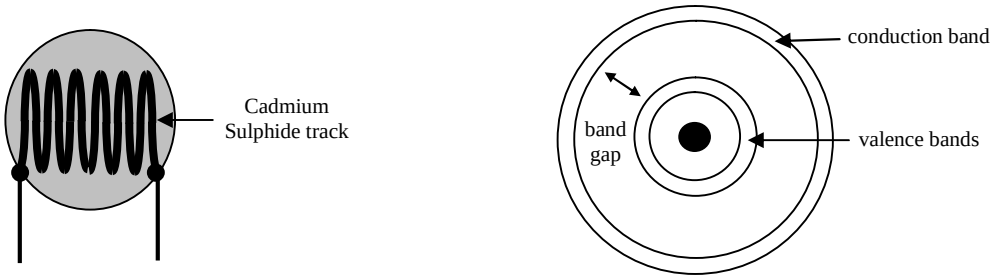

Figure 2.4: Structure of a Light Dependent Resistor, showing Cadmium Sulphide track and an atom to illustrate electrons in the valence and conduction bands.

2.3 Direct Current Motor

There are several types of DC motors that are available. Their advantages, disadvantages, and other basic information are listed below in the Table 2.1.

DC motor works by converting electric power into mechanical work. This is accomplished by forcing current through a coil and producing a magnetic field that spins the motor. The simplest DC motor is a single coil apparatus, used here to discuss the DC motor theory. [1]

The voltage source forces voltage through the coil via sliding contacts or brushes that are connected to the DC source. These brushes are found on the end of the coil wires and make a temporary electrical connection with the voltage source. In this motor, the brushes will make a connection every 180 degrees and current will then flow through the coil wires. At 0 degrees, the brushes are in contact with the voltage source and current is flowing. The current that flows through wire segment C-D interacts with the magnetic field that is present and the result is an upward force on the segment. The current that flows through segment A-B has the same interaction, but the force is in the downward direction. Both forces are of equal magnitude, but in opposing directions since the direction of current flow in the segments is reversed with respect to the magnetic field. At 180 degrees, the same phenomenon occurs, but segment A-B is forced up and C-D is forced down. At 90 and 270-degrees, the brushes are not in contact with the voltage source and no force is produced. In these two positions, the rotational kinetic energy of the motor keeps it spinning until the brushes regain contact. [1]

One drawback to the motor is the large amount of torque ripple that it has. The reason for this excessive ripple is because of the fact that the coil has a force pushing on it only at the 90 and 270 degree positions. The rest of the time the coil spins on its own and the torque drops to zero. The torque curve produced by this single coil, as more coils are added to the motor, the torque curve is smoothed out. [1]

The resulting torque curve never reaches the zero point and the average torque for the motor is greatly increased. As more and more coils are added, the torque curve approaches a straight line and has very little torque ripple and the motor runs much more smoothly. Another method of increasing the torque and rotational speed of the motor is to increase the current supplied to the coils. This is accomplished by increasing the voltage that is sent to the motor, thus increasing the current at the same time. [1]

Table 2.1 Advantages and disadvantages of various types of DC motor

.

Type	Advantages	Disadvantages
Stepper Motor	Very precise speed and position control. High Torque at low speed.	Expensive and hard to find. Require a switching control circuit
DC Motor w/field coil	Wide range of speeds and torques. More powerful than permanent magnet motors	Require more current than permanent magnet motors, since field coil must be energized. Generally heavier than permanent magnet motors. More difficult to obtain.
DC permanent magnet motor	Small, compact, and easy to find. Very inexpensive	Generally small. Cannot vary magnetic field strength.
Gasoline (small two stroke)	Very high power/weight ratio. Provide Extremely high torque. No batteries required.	Expensive, loud, difficult to mount, very high vibration.

2.4 Omron 24Vdc Relay.

A relay is a simple electromechanical switch made up of an electromagnetic and a set of contacts. Relays are found hidden in all sorts of devices. In fact, some of the first computers ever built used relays to implement Boolean Gates.[4]

Relays are amazingly simple devices. There are four parts in every relay:

- Electromagnet
- Armature that can be attracted by the electromagnet
- Spring
- Set of electrical contacts

The following figure shows these four parts in action:

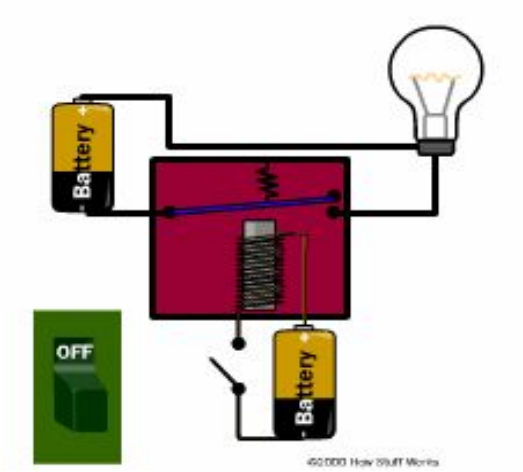

Figure 2.5: Simple relay circuit.

In this figure, you can see that a relay consists of two separate and completely independent circuits. The first is at the bottom and drives the electromagnetic. In this circuit, a switch is controlling power to the electromagnet. When the switch is on, the electromagnet is on, and it attracts the armature (blue). The armature is acting as a switch in the second circuit. When the electromagnet is energized, the armature completes the second circuit and the light is on. When the electromagnet is not energized, the spring pulls the armature away and the circuit is not complete. In that case, the light is dark.[4]

When purchase relays, you generally have control over several variables:

- The voltage and current that is needed to activate the armature
- The maximum voltage and current that can run through the armature and the armature contacts
- The number of armatures (generally one or two)
- The number of contacts for the armature (generally one or two -- the relay shown here has two, one of which is unused)
- Whether the contact (if only one contact is provided) is normally open (NO) or normally closed (NC)